Sources of Treatability Data

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The 1994 amendments to the state *Dangerous Waste Regulations* include a revision of the domestic sewage exclusion (WAC 173-303-071). This revision requires that certain hazardous wastes must be treatable in the publicly owned treatment works (POTW) where they will be received if they are to be considered for a discharge permit or authorization. The permit authority (Department of Ecology and delegated POTWs) will decide the treatability of such wastes based, in part, on data provided by the applicant.

The exclusion specifies that treatability must be determined for the waste before mixing it with domestic sewage. This is important since concentration can influence treatability. In addition, pollution prevention and source reduction techniques, pretreatment standards, and additional treatments required by Ecology must be applied to the waste before determining its treatability.

This document reviews the data sources used to support treatability determinations. It is meant as a guide for permit writers, sewer authorities, applicants, and consultants who may assist applicants.

Overview of Treatability Information

Treatability determinations for discharge of toxics to POTWs have two main components: determining the **fate** of toxics in a POTW, and evaluating their potential for biological **inhibition**.

Fate determinations estimate the biodegradation of the compound of interest and its distribution into the air, effluent, and biological solids of the POTW. Applicants can derive fate data from testing or from scientific literature and reference manuals. They can also extrapolate fate data based on certain chemical characteristics, or by using computer models to combine chemical information with the characteristics of a specific treatment plant.

Fate information must be used in conjunction with **inhibition data**. A toxic compound present at a concentration that inhibits the biological action of a POTW's microorganisms will impair the biodegradation of that compound. Inhibition data appears in scientific literature and reference manuals, or can be derived through testing. Sometimes, microorganisms acclimate to the presence of a toxic compound. This adaptation reduces the ability of the compound to inhibit biodegradation. Little information exists on long-term acclimation effects that may counter inhibition.

Chemical Characteristics Data

Chemical characteristics can give clues to the treatability of a compound. Characteristics such as volatility, solubility, molecular

weight, density, biodegration rate constants and sorption coefficients affect the treatability of toxics entering a sewage treatment system. Many printed volumes of chemical data are available, as well as computerized data bases. This information is best combined with a knowledge of treatment system parameters such as aeration rates, detention times and solids concentration, among others. Computerized fate models usually contain their own data bases of chemical characteristics, and they have the advantage of combining this information with actual operational parameters for the specific POTW under consideration (see the section on computerized fate models).

The annotated reference list of this report lists several handbooks with chemical data useful for deciding treatability. In addition, electronic sources of chemical characteristics and removal efficiency data are also given.

Literature

Scientific and professional journals contain many papers and articles on the treatability of specific compounds and waste streams. Searches for this information can be conducted through university libraries, the Washington State Library (360-753-5590), EPA's Region 10 library (206-553-1289), the Department of Ecology library (360-407-6152), and the METRO library (206-689-3051).

Several EPA manuals commonly have been used as sources of treatability information. This information includes generalized removal efficiencies, chemical characteristics and inhibition concentrations. The annotated reference list of this report lists EPA publications containing treatability data. These documents can be obtained through the mentioned libraries.

Some reported data show inconsistencies resulting from factors such as variable treatment processes and operational parameters; scale of the treatment process; antagonistic/synergistic effects; degree of acclimation at the POTW receiving the waste; differing influent concentrations; and inconsistent sampling, handling, and analytical techniques. These factors make it difficult to group data from different POTWs, or to assume the applicability of data to any other POTW.

Bench-Scale Testing

Bench-scale testing provides laboratory information on the potential biodegradation and/or inhibitory effects of toxic compounds or complex waste streams. No standards or widely-established protocols exist for bench-scale testing of biodegradation or inhibition. Several popular methods are given below. All of the techniques share a potential problem of not accurately reflecting the treatability of the wastewater in an actual POTW. Methods allowing use of sludge microorganisms acclimated to the compound of interest may provide data on the long-term effects of a toxic on a POTW.

5-Day BOD

One simple method of evaluating inhibition due to an industrial waste adds incremental volumes of the waste to dilution water seeded with sewage sludge and analyzes it for 5-day BOD. If the waste is inhibitory to the POTW bacteria, higher concentrations of the waste will result in less oxygen depletion and lower BOD. If relatively biodegradable, larger volumes of the waste should produce proportionately higher oxygen depletion. The technique can estimate the concentration at which the waste becomes inhibitory. The major disadvantages are the five day waiting period and the questionable correlation between degradation in a BOD bottle as compared with a full-scale biological reactor.

Respirometry

Respirometry can also measure the oxygen uptake of POTW bacteria. Adding a compound that causes the bacteria to increase their utilization of oxygen is interpreted to mean that the compound is biodegraded. Some researchers define inhibition as conditions where the oxygen uptake of microorganisms, with addition of the test compound, is less than the oxygen uptake without adding the test compound. They define toxicity as the condition of no oxygen uptake, an indicator of little biological activity.

Photo-luminescence

This method uses photo-luminescent marine microorganisms whose light output decreases proportionally to their level of toxic shock when fed varying concentrations of waste. The method can evaluate the toxicity of influent to the POTW, and it can measure toxicity reduction through the treatment process. This method may be more sensitive than respirometry at low concentrations. One disadvantage for measuring plant interference is that it does not use POTW organisms. Test time is 5-15 minutes.

TOD, COD

Theoretical oxygen demand of a specific compound is calculated based upon the complete oxidation of the chemical to CO_2 and water. Some researchers use COD as a yardstick to compare degradation test results.

Dehydrogenase Activity

Measurement of dehydrogenase enzyme activity measures the metabolic activity of the cell itself. This test uses a reducible dye whose concentration is a measure of dehydrogenase activity. A spectrophotometer measures the amount of reduced dye present. Some substances, such as metal ions, sulfides and humic substances can interfere with the test. Temperature, pH and oxygen concentration may affect the test results.

ATP Activity

Measurement of the adensosine triphosphate (ATP) pool indicates the number of viable cells. It also measures cell activity. It is necessary to measure response to toxicants during endogenous phase of cells and without substrate addition.

Sludge Respiration

The sludge respiration test involves spiking a standard amount of synthetic sewage with different concentrations of test substance, and adding it to aerated standard prepared sludge. The oxygen uptake rate is measured after thirty minutes and after three hours. This test attempts to eliminate some of the variability of respiration tests.

Michael J. McGrath (1988 masters' thesis for the University of Massachusetts) compared literature evaluations of the above test methods and reached the following conclusions:

"The dehydrogenase activity test was inexpensive, rapid, easily conducted, reliable, but not reproducible or sensitive. The ATP activity test was inexpensive, rapid, easily conducted, sensitive, but not reproducible or reliable. The Microtox photo-luminescence test was inexpensive, rapid, easily operated, reproducible, reliable, and sensitive. The BOD_5 inhibition test was inexpensive, easily conducted, and sensitive, but was not rapid, reproducible or reliable. Respirometry was found to be inexpensive, rapid and sensitive; but no easily operated, reproducible, or reliable. The sludge respiration test was inexpensive, rapid, easily conducted, reproducible, reliable, and sensitive.

Activated sludge inhibitory concentrations and Microtox [photo-luminescence] toxic concentrations were of the same order of magnitude....Laboratory experiments compared three microbial toxicity tests. Based on the modifications used in these experiments,

Microtox was the most sensitive of the three tests. The modified BOD_5 inhibition test was generally the next most sensitive test. The modified sludge respiration inhibition test exhibited stimulation for most of the chemicals tested."

Fate Models

Computerized fate models estimate the effects of biodegradation, sorption onto solids, and volatilization on substances entering a treatment system. Most fate models provide data on percent distribution, mass loading, and concentration of the substance in the effluent, solids and air from the POTW. The models vary in the size of their chemical data base, the number and types of their unit processes, the sources of their data and other features.

The following is a brief review of the most prominent computerized fate models currently available.

TOXCHEM

TOXCHEM+, the Windows upgrade of TOXCHEM 1.1, will allow modeling of activated sludge, fixed film, lagoon, closed tanks and industrial pretreatment systems, and also collection system effects and split flows. It includes a large database of 126 substances backed by extensive bench-, pilot, and full-scale testing. It is the only fate model that includes metals. By entering effluent, sludge and air permit levels, the model can be "run backward" for maximum headworks loadings. Version 1.1 allows dynamic (non-steady state) modeling of slug flows. The ability to perform sensitivity analyses allows estimation of the effects of parameter variations. TOXCHEM is one of the three fate models accepted by EPA for estimating VOC emmissions from POTWs. TOXCHEM is available for Enviromega Ltd., Ontario, Canada (phone 905/689-4410, fax 905/689-7040.

BASTE 3.0

BASTE estimates losses of organic compounds from wastewater treatment processes due to volatilization, sorption and biodegration. Its primary use is to model air toxics emissions. Its data base contains 26 volatile organics, but the user may enter data for other compounds. It does not model metals. BASTE has been authorized by EPA for estimating VOC emissions from POTWs. BASTE is available from CH2MHILL at 510/251-2888, extension 2165.

WATER8 / CHEMDAT8

EPA designed WATER8 / CHEMDAT8 to estimate VOC emissions from POTWs. It includes modeling of trickling filters, surface impoundments and also more common POTW processes. The program does not include sludge processing, and the user must hand calculate sludge concentrations. A large selection of organics is offered, but many chemical characteristics are based on theoretical analysis rather than empirical test results. It does not include metals. WATER8 can be downloaded by modem from the Technology Transfer Network (TTN) at no cost by dialing 919/541-5742. Computer assistance is available by dialing 919/541-5232.

FATE Version 1.0

EPA's Fate and Treatability Estimator (FATE) model was developed to model conventional activated sludge at POTWs. The data base, which may contain some outdated or estimated data, contains 190 organic and incorganic compounds, but no metals. It can be obtained from NTIS for $55 by calling 1-800-553-6847.

Annotated Reference List

Clement Associates, Inc., *Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites: Final Report*, September 27, 1985 Chemical and physical data useful for determining the fate of toxic compounds.

Howard, Philip H. et al, *Handbook of Environmental Fate and Exposure Data for Organic Chemicals*, Lewis Publishers, Inc., 1989 Tables of chemical characteristics affecting the fate of toxics in a POTW.

Industrial Technology Division, Office of Water Regulations and Standards, Office of Water, *CERCLA Site Discharges to POTWs Guidance Manual*, Document # EPA/540/G-90/005, August 1990 Reported threshold concentrations for biological inhibition by organic and inorganic compounds. Examines inhibition in activated sludge, nitrification and anaerobic digestion.

Industrial Technology Division, Office of Water Regulations and Standards, Office of Water, *CERCLA Site Discharges to POTWs Treatability Manual*, Document # EPA/540/2-90/007, August 1990 Mean, minimum and maximum percent removals for activated sludge, trickling filter and aerated lagoons, based on a literature search.

Pajak, Andrew et al, *Effect of Hazardous Material Spills on Biological Treatment Processes*, Document # EPA-600/2-77-239, December 1977 Compilation of literature data on biological inhibition and removals in biological treatment processes.

Mackay, Donald et al, *Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals*, Lewis Publishers, 1993 Five volume series. Excellent resource for physical-chemical characteristics affecting the fate of organic chemicals.

Schnoor, Jerald et al, *Processes, Coefficients, and Models for Simulating Toxic Organics and Heavy Metals in Surface Waters*, Document # EPA/600/3-87/015, June 1987 Excellent resource for chemical characteristics.

United States Environmental Protection Agency, *Fate of Priority Pollutants in Publicly Owned Treatment Works: Final Report, Volume I*, Document #EPA 440/1-82/303, September 1982 Minimum and median percent removals of priority pollutants, based on a field study of selected POTWs.

United States Environmental Protection Agency, *Guidance Manual for Preventing Interference at POTWs*, September 1987 Includes data on inhibition by metals and some inorganic compounds for activated sludge, nitrification and anaerobic digestion. Inhibition ranges are estimated for several broad classes of organics.

United States Environmental Protection Agency, *Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program*, December 1987 Generalized priority pollutant removal efficiencies from primary, tertiary, activated sludge and trickling filters. Priority pollutant inhibition threshold levels for activated sludge, nitrification and anaerobic digestion.

United States Environmental Protection Agency, *Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works*, Document #EPA/530-SW-86-004 Contains RREL removal estimates and extensive inhibition data.

Verschueren, Karel, *Handbook of Environmental Data on Organic Chemicals*, New York, Van Nostrand Reinhold, 1983 Tables of chemical characteristic affecting the fate of toxics in a POTW.

Computer Data Bases

The following are computerized data bases providing treatability data. Refer to the section on Computerized Fate Models for additional information:

CHEM-BANK

Provides five complete data bases on one compact disk. Includes RTECS, HSDB, IRIS, OHMTADS, CHRIS. Available from Silver Platter Information, Inc., 100 River Ridge Drive, Norwood, MA, 02062, 1-800- 343-0064

RREL

EPA treatability data base superseding WERL. Provides chemical characteristics and removal data with references. Available from EPA's Risk Reduction Engineering Laboratory by calling Glenn Shaul at 513/569-7408 or Thomas Holdsworth at 513/ 569-7675 (Fax: 513/569-7787)

TOXNET

On-line service from the National Library of Medicine providing access to 11 data bases, including HSDB, IRIS, RTEC, TRIFACTS. Available from Specialized Information Services, National Library of Medicine, 8600 Rockville Pike, Bethesda, MD 20894, 301/ 496-6531.

FATE, The Environmental Fate Constants Information Database

A new EPA on-line data base of kinetic and equilibrium constants needed for assessing the fate of chemicals in the environment. Subscribe by calling Maria Hodge 703/487-4630, or 703/ 487-4679.

Environmental Fate Data Base

Available in on-line and PC versions, this data base contains chemical characteristics and biodegradation data for thousands of compounds. Available from Syracuse Research Corporation, Merrill Lane, Syracuse NY 13210 (Phone 315/426-3350, Fax 315/426-3429).

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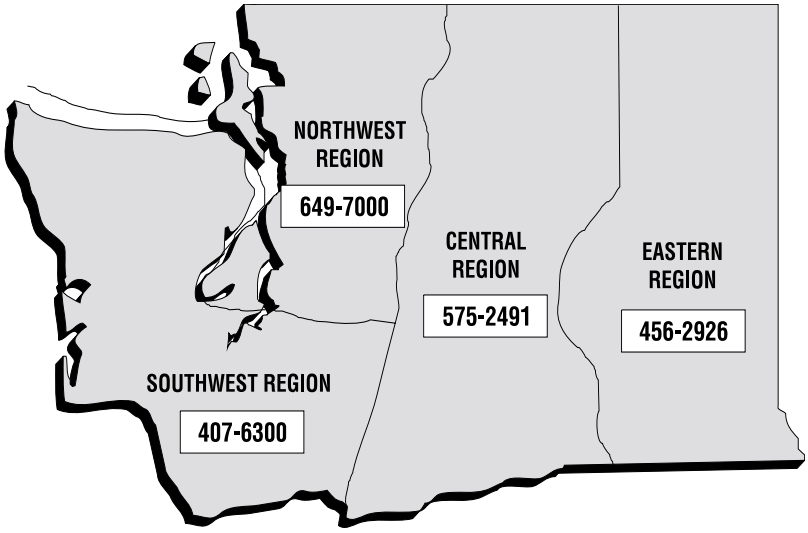

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